EXPERIMENTS WITH ANTS INDUCED TO SWIM.

BY ADELE M. FIELDE.

The behavior of ants often appears to originate in mental processes,[1] and the myrmecologist is perpetually lured to further experiment by a tantalizing expectation of ascertaining whether the cause of their action be psychic.

One afternoon in the summer of 1901 I inadvertently left, upon the base of a Lubbock nest in the laboratory, a score or two of ants, *Stenamma fulvum*, with a few of their larvæ and a little damp earth. Before the next noonday they had built with particles of the earth what looked like a roundish hut, not more than two centimeters long, with a doorway and a smoke-hole. Its outside shape was like that of the interior of one of their recesses in their wild nests. They had carried their larvæ into it, and had thereby screened them from light and from the wind. The air of the room was dry, and after a few hours the edifice disintegrated from the evaporation of its moisture.

These ants live under loose stones and among the roots of grasses, and do not build habitations on a surface. In opening scores of their nests, I have never found any similar structure. The little hut seemed to be evidence of a purposeful adjustment to new conditions.

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[1] In August, 1903, I left upon the bottom of a dish, surrounded by water in a larger dish, about seventy *Lasius latipes* workers, with fifty of their tiny cocoons, in two centimeters of earth, covered by a pane of orange glass ten centimeters long and eight centimeters broad. Such glass excludes, partially but not wholly, the ultra-violet light-rays always avoided by the ants. The earth extended about four centimeters beyond the glass. There was a morsel of food on the glass.

The ants had been undisturbed and unobserved for ten days, when I saw that they had nearly covered their roof-glass to the depth of about two millimeters with particles of earth. Many of the particles were half as long as the longest of the ants, and certainly heavier than any one of them, and could not have been laid on the glass without considerable effort on the part of the ants. This overlaying of the glass secured darkness for the workers and the young under the glass; and numerous runs with exits outside the edge of the glass had been made in the earth below, as is done in their wild nests under stones.

Thinking that the presence of the food on the glass might have influenced the deposit of the particles of earth, I removed the food to the end of the dish, washed the glass clean and replaced it. In a few days the ants had again covered the glass with like particles of earth. The work was always carried on in the night, and I did not witness its performance.

I made a similar arrangement of dishes, earth and glass for *Stenamma fulvum*, but these ants did not overlay their semi-transparent roof.

On August 29, 1903, I placed about fifty workers and three queens of this same species, with a half-teaspoonful of their pupæ, upon the base of the same Lubbock nest, in the same place in the same room,[2] hoping that they would again build a hut for their young during the ensuing night. I had many tens of times put *Stenamma fulvum* on this board, with their nest-earth and young, and they had never once escaped by swimming. The board is square, thirty-eight centimeters broad and four centimeters high. On its upper surface, about a centimeter from its edge, there is a channel having a flat bottom and vertical sides, two centimeters deep and from twenty-six to thirty millimeters wide. When this channel is filled with water an island about thirty centimeters square is formed by the central portion of the board. The ants were on this island, and their kind had never manifested ability to swim across the surrounding channel. These individual ants were habitants of a nest located at a considerable distance from any body of water, and they could have had no previous experience in swimming. I was therefore astonished on the following morning in finding that the ants, instead of building huts for their young, were carrying it to a crevice forty centimeters from the island, between the supporting table and the wall of the room. Two of the queens had gone, and one queen remained with a group of newly hatched callows. The labor of transporting the callows continued all day. I was curious to see how the queen would reach the crevice, as no ant travels far on any path before untraversed by her. As soon as the queen crossed the channel there was increased excitement among the ants. Several of the larger ones approached the queen, and one of them lifted her free from the edge-way and carried her to the crevice. All the remaining callows and the pupæ were likewise carried to the crevice, and at nightfall not an ant remained on the island, nor had any dead ants nor deserted pupæ been left in the channel. The exodus had occupied thirty hours.

When crossing the channel without a burden the smallest ants walked on the surface of the water. Heavier ones clawed the surface with the fore feet, walked with the middle pair and trailed the hinder ones. The degree of submergence greatly varied. When carrying a burden the ant swam with the legs wholly submerged, only the tarsi of the hinder ones being above the surface. The antennæ waved constantly and progress was very slow. Ants without burdens were from ten to sixty seconds in crossing the channel, while burdened ones

[2] These experiments were all made in the Marine Biological Laboratory at Woods Hole, Mass.

2. Of twenty-two ants, without burden, on their way from the island to the edgeway, seventeen turned themselves in the water and went to the edgeway. Five failed in the effort to turn and went back to the island.

3. Of five ants, with burdens, on their way from the island to the edgeway, four turned themselves in the water and swam to the edgeway. One, after a long struggle, landed on the island.

4. A burden-bearer, on her way from the island to the edgeway, was gently turned around by me when she was in mid-channel and caused to land upon the island at her starting-point. She was manifestly bewildered. Holding on to her charge, she wandered about over the island for twenty minutes, then returned to the place of her landing, laid down her burden, swam across the channel to the edgeway and back again, picked up her burden, crossed the channel again and went to the nest.

Dead ants, or flecks of wood or yarn of the same size as an ant, when cast upon the water and turned by its swirling in the same way as that in which I turned the ants, did not revert to their former positions. The volition of the ant, not the force of the water, was the cause of the semi-revolution made by the ant in turning back upon her course. She can orient herself upon trackless water, as well as upon a tracked solid, but in either case her environment must have been previously explored.

I then undertook tests showing whether the ant could orient herself when removed from the shortest line between the end of her path on the one shore and its beginning on the other shore.

Test f.—When the ant was on her way to the island, and in mid-channel, I placed the nozzle of a bulb-syringe at a distance from the swimmer and very gently drew the water and the ant several centimeters out of her line of crossing and in the direction of the length of the channel, without changing the direction of the ant's body. Of twenty-eight ants thus drawn away from their position, all gave marked signs of bewilderment. Some ceased for a long time from swimming; some made a complete revolution sidewise; some plunged deeper; some swam up and down the channel. That they had lost their bearings was as evident as if they had been upon a solid, although their movements were more limited in range. Twelve of these ants finally landed on the island and fourteen landed on the edgeway.

Of five other ants crossing with burdens from the island to the edgeway, all were similarly bewildered by being drawn away from

assuring them in a touch of the antennæ that they were nearing a foothold.

Again, all the swimmers, with or without a burden, crossed the channel at right angles to its length. The swimming ants varied in length from five to seven millimeters, but the longest ones rarely repassed the channel, and the transits were made chiefly by ants from five to six millimeters long. They therefore had to swim at least twice their length after relinquishing one shore before they touched the other. They always lingered long on the brink, running to and fro; entered the water with much hesitation, and relinquished the shore with delay. I supplied as much water as was lost by evaporation, and kept the surface of the channel nearly level with that of the island and the edgeway. The concavity of the meniscus was slight, but capillarity always hindered the ant in her departure at one shore and somewhat accelerated her arrival at the other shore.

My first experiments were made with a view to ascertaining whether the ants laid each an individual track across the water, as is always done in traversing a solid.

Test a.—I selected ants that must have crossed the water at least once, because they were returning to the island, and when they had released their hinder feet from the edgeway, I took, with a pipette having a curved point, some drops of water from the surface of the water directly in front of the swimmer. Of thirty-one ants, twenty-one went immediately on their way to the island, and ten turned back to the edgeway. The taking of the water may not have caused all of the ten to turn back, since many other ants, finding the struggle of crossing too great, turned back when the water was untouched. Had the ants that continued on their way had a track previously laid on the water, it would probably have been destroyed by my action, and the twenty-one ants would also have turned back.

Test b.—Choosing an ant that was returning to the island, while she was in mid-channel, I passed a knife-blade five millimeters broad several times around the ant, penetrating the water to half its depth. Of ten ants thus encircled none turned back.

Test c.—I swept the floor of the room violently, raised much dust, and left the channel untouched during the ensuing twenty-four hours. I then counted the ants that crossed the channel during a half-hour, and found that twenty-one passages were made to the island and twenty-five away from the island. The latter number included four ants with burdens. With a shred of cloth I then brushed the dust

from the whole surface of the channel, being careful not to touch its shores. I then counted all the ants that crossed during the ensuing half-hour. Twenty passages were made to the island, and twenty-two were made from the island. The latter number included two burden-bearers. The close correspondence of numbers is explained by the fact that a few individuals among the ants do most of the work undertaken.

After the removal of the dust, with displacement of the particles of water over the whole surface of the channel, there was among the ants no action indicating either a difficulty in pursuing their routes, or a necessity for laying new tracks across the channel.

Test d.—I next considered only ants that had taken up a burden to carry away from the island, and when I saw one of these about to enter the water, I swept its surface with a little cloth broom that extended nearly across the channel. Fifteen burden-bearing ants crossed over water whose particles had just been disturbed to a depth of several millimeters. Their course was as direct and their time of crossing was as brief as that of burden-bearers whose path had not been thus swept.

These tests show that the ants did not depend on a previously laid track when they crossed the water. They evidently expected to find the water in the place where they had previously encountered it. Each ant pursued her laid track on the wood to the edge of the channel, and then orienting herself by something other than her track, she crossed and picked up her track on the opposite shore.

Bethe's well-known hypothesis, that the ants orient themselves through a polarization of the scent laid down by their feet, is surely inapplicable when the ants have no track, and keep to their bearings without one.

The difficulty of crossing the channel was greatly increased when the ant was forced to turn herself in the water in order to pursue her route, but even under this arduous strain most of the ants maintained their course.

Test e.—With a small knife-blade I swirled the water when the ant was in mid-channel, so as to turn the swimmer once or more around, leaving her with her head toward the shore from which she had just come. The results were as follows:

1. Of nineteen ants, without burden, on their way from the edgeway to the island, fifteen turned themselves in the water and swam to the island. Four failed in the effort to turn and went back to the edgeway.

2. Of twenty-two ants, without burden, on their way from the island to the edgeway, seventeen turned themselves in the water and went to the edgeway. Five failed in the effort to turn and went back to the island.

3. Of five ants, with burdens, on their way from the island to the edgeway, four turned themselves in the water and swam to the edgeway. One, after a long struggle, landed on the island.

4. A burden-bearer, on her way from the island to the edgeway, was gently turned around by me when she was in mid-channel and caused to land upon the island at her starting-point. She was manifestly bewildered. Holding on to her charge, she wandered about over the island for twenty minutes, then returned to the place of her landing, laid down her burden, swam across the channel to the edgeway and back again, picked up her burden, crossed the channel again and went to the nest.

Dead ants, or flecks of wood or yarn of the same size as an ant, when cast upon the water and turned by its swirling in the same way as that in which I turned the ants, did not revert to their former positions. The volition of the ant, not the force of the water, was the cause of the semi-revolution made by the ant in turning back upon her course. She can orient herself upon trackless water, as well as upon a tracked solid, but in either case her environment must have been previously explored.

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Of five other ants crossing with burdens from the island to the edgeway, all were similarly bewildered by being drawn away from

position, and were many minutes in reaching shore. Three of them landed on the island and two of them landed on the edgeway.

Dead ants or flecks of wood or yarn, subjected to the same conditions, did not behave as did the ants, and made no similar movements.

Test g.—When an ant was returning to the island, and was in mid-channel, I pushed the water with the cloth broom, so that the swimmer would be borne on the water to a distance of a centimeter or two off the line by which she would have crossed if the water had remained untouched, but keeping the axis of the ant's body parallel to that line. Of nine ants thus moved five went on to the island and four turned back to the edgeway. The evidences of bewilderment were much less marked than when the ants were drawn to a distance of several centimeters from their position.

It is plain that the ants did not orient themselves from their own track where no track existed. Far less of manipulation than was spent upon the water will destroy the track of these ants upon a solid. They must have traversed the distance across the channel depending for their orientation on something other than their immediate foot-prints. Their lesser bewilderment when they were moved a lesser distance from their position, indicates that they orient themselves by something that is not far removed from them. This may be the remembered odor of objects at very short distances one from another, recognized for guidance from point to point, as is supposed by Forel.

The ants gave no indication that they had an intellectual conception of the island on which they spent many days, nor of its surrounding channel, whose edgeway they seemed to everywhere explore. They gave no sign of an idea that if they crossed the water at any point they could reach a solid and their destination. They were manifestly guided by what was very minute in size and very near in position. But these minute things must be remembered, since the ant rightly orients herself by them after absences of considerable length.

The queens were shoved off the island by the workers. They drifted rather than swam to the edgeway, were hauled out by waiting workers and carried by them to the nest. Many of the callows were carried all the way from the island to the nest, while others followed adult workers, all the time touching the leader with the antennæ. Occasionally three ants crossed thus in file.

On the morning of September 9, ten days after the ants had been placed on the island, only one queen and seven workers remained there. All the five queens without antennæ had been transported to the nest, as had all the young. No loss of life or of young had oc-

curred, with the exception of about twenty newly hatched callows that had succumbed to the adverse conditions attending their hatching.[4]

[4] I append an irrelevant note concerning an abnormal form, uncommon in my ant-nests.

On August 25, 1903, I found, in one of my artificial nests of *Stenamma fulvum*, a recently hatched gynandromorphic ant, bilaterally asymetrical. The size, form, color and wings on the left side were those of the normal male, while the right side was in all respects like that of a normal worker.

Regarding such abnormal insects, Boveri (*Ueber Mehrpolige Mitosen als Mittel zur Analyze des Zellkerns*, 1902) presents the hypothesis that the first cleavage of the egg, marking the future axis of the body, occurred previous to fertilization; that the spermatozoan then entered one blastomere, producing on that side the female form, while the other blastomere developed parthogenetically into the male form.